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METHOD AND DEVICE FOR THE DETECTION AND IDENTIFICATION OF A HELICOPTER

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16 Abstract

The invention concerns a method for detecting and identifying a helicopter based on its characteristic emission of energy in the visual and infrared regions as well as acoustic energy by employing a fire control computer with data storage and a device for targeting and observation.

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Patent Claims:

1. Method for detecting and identifying a helicopter based on its characteristic emission of energy in the visual and/or infrared region as well as acoustic energy, employing a targeting and observation device which stores data in the fire control computer. The targeting and observation device is characterized by the application of a detection sensor (8) exploiting the helicopter's characteristic as a source of infrared energy, an identification sensor (11) working on the background visual light modulated by the helicopter, or the modulated characteristic emissions of the rotor, and, for the determination of the position on the horizon an horizon sensor, controllable in elevation relative to the two other sensors. The azimuth and elevation angles for the helicopter are sent to the fire control computer automatically and the targeting and observation device and weapon are simultaneously aligned on the target.

2. Method in claim (1), in which the individual azimuth and elevation coordinates of targets identified as false targets are stored in a computer for use in a threat estimation and the subsequent initiation of countermeasures.

3. Method of claims (1) and (2), in which the positions in azimuth of the known false targets are used to stop the identification sequence over a certain azimuthal range during at least the following pass of the sensors.

4. Device for performing the method of one of the preceding claims in which the sensors (8; 11; 14) are integrated in a common sensor head, arranged adjacent to each other in a row.

5. Device as in claim (4), in which the sensor head (1) is in the form of a periscope, rotatable in azimuth around its vertical axis of symmetry, in which the elevation angle and horizon information is controllable with mirrors (4;12) integrated with the sensors (8; 11; 14) (Fig. 1)

6. Device as in claim 5, in which the motions of both mirrors (4; 12) are independent from one another. (Fig. 1 and 3)

7. Device as in claims 5 and 6, in which the sensor head can be rotated in azimuth by means of a ball bearing (2) attached to its outer casing. (Fig. (1))

8. Device as in claim 4, in which the sensor head is in the form of a fork rotatable in azimuth around its vertical axis of symmetry (17), in whose arms a shaft is mounted, (15) perpendicular to the axis of symmetry and carrying the three sensors (8; 11; 13) so that they are free to move in elevation (Fig. 2)

9. Device for carrying out the method in claim 1, in which the sensors (8; 11; 14) are provided with at least one common objective lens (7, 10, 13 or 21) and the rays for the horizon sensor (14),which uses a spectral region different from the other two sensors (8,11), are filtered with at least one splitter (6; 9).

10. Device as in claim 9, in which the combined objective lens (21) is built up from a broad band lens designed for the horizon sensor's spectral range of 1.8 to 2.7 µm and approximately 3.0 to 5.5 µm and the detection and identification sensors' (8; 11) wavelengths of 8.5 to 12.5 µm.

11. Device for carrying out the method in one of the preceding claims, in which the detection sensor (8) and the identification sensor (11) are integrated in a common Dewar flask (22).

12. Device for carrying out the method in one of the preceding claims, in which the detection sensor (26) is made up of N individual detectors (8) arranged one above another and of identical dimensions, and is movable in the horizontal direction (24). (Fig. 4)

13. Device for carrying out the method in one of the preceding claims, in which the the identification sensor (11) is in the shape of a rod (30) of the greatest possible ratio of length to width (Fig. 5)

14. Device as in claim (13), in which the rod-shaped sensor (30) is aligned horizontally (i.e. parallel to the most probable orientation of the rotor blades) and is set up to follow the detection sensor (8) as the sensor head moves in azimuth.

15. Device for carrying out the method in one of the preceding claims, in which the sensors are fitted with an acoustic identification sensor (18) consisting of directional microphones (18; 20) moving along with the sensors in azimuth and elevation.

16. Device as in claim 12 in which the oscillatory frequency of the horizon sensor's mirror (12) is tuned to the rotational speed of the sensor head (1) and the amplitude of its motion is greater than the instantaneous angular size in elevation of the field of view covered by the detecion sensor (26).

17. Device as in claim (5) in which the position of the horizon can be determined and used to position the detection sensor (8) in elevation with the rotatable mirror (4), using an angular position transducer mounted on the scanning mirror (12) of the horizon sensor (14).

The invention concerns a method for detecting and identifying a helicopter based on its characteristic emmission of energy in the visual and infrared regions as well as acoustic energy by employing a fire control computer with data storage and a device for targeting and observation.

With the introduction of antitank helicopters (German Abbreviation: PAH) with long range antitank missiles a new aerial threat arises for the tank which can only be opposed with weapons and other countermeasures if the tank succeeds in detecting the helicopter and identifying it while it is still at a long range. This is made difficult by the fact that the attack helicopter is sent in against previously reconnoitered targets; i.e. the approximate position of the target is known. The helicopter exploits every naturally occurring hiding place available to it in order to sneak its way at very low altitude until its antitank missiles are within range of the target. The tank must therefore expect the helicopter to appear under or directly above the horizon. Since it is not constrained to move on the ground, the helicopter can also attack from every conceivable direction in the sky. Once in the operational area, the helicopter can search for a target by climbing vertically and loitering at an altitude which allows him a view of the area, and after acquiring

and selecting a target can initiate the attack sequence, which by experience lasts 10 to 20 seconds. It can therefore be assumed that the tank can see the helicopter a maximum of 20 to 40 seconds before it is struck by an antitank missile. For the tank, the detection and reaction times must be correspondingly small.

DE-AS 20 21 817 discloses a device for seeking and following a target with the help of sensors detecting infrared energy emitted by the target. Azimuth and elevation angle data are sent to a fire control computer. However, it is necessary for the approximate position of the target to be known in advance. With this device it is not possible to decide if the the heat emitting point is a helicopter at all, to say nothing of determining its type.

R. D. Hudson, in "Infrared System Engineering", John Wiley & Sons 1969, discusses the heating of an object moving through the atmosphere at high speed, but not the detection and identification of a helicopter. U. S. Patent 27 74 961 deals with an identification sensor which detects moving objects emitting infrared energy, with which it is also not possible to identify a helicopter.

Furthermore, U.S. Patents 27 40 961 and 29 99 161 as well as DE-OS 25 19 840 disclose various horizon sensors for application in ships and flight vehicles (missiles, aircraft,

spacecraft). They give however no indication as to their applicability to the detection and identification of a helicopter based on its characteristic emissions.

Finally, "Wehrtechnik" ("Defence Technology"), 3/72, pp. 112-118 discusses the transmission of sensor data to a fire control computer for the purpose of aiming the weapon.

The purpose of the invention lies in the development of a means for a tank to detect a helicopter; in particular an antitank helicopter, appearing below or directly above the horizon, as quickly as possible and to identify it so that the appropriate countermeasures can be initiated. This problem is solved by the structure described in claim no. 1.

Such a methoddepends on the infrared radiation from the attack helicopter and the rotor blades, which are heated by air resistance. The elevation angle is determined relative to the vertical axis in order to monitor a specific angle above and below the horizon and to reduce the required range of elevation angles to a minimum. The horizon sensor employed here can also be used to provide control signals to direct the infrared sensors along the horizon within a limited azimuth angle. In so doing the difference in background infrared radiation between the relatively cold sky and the warm ground is exploited. The detection, identification, and horizon sensors operate in the infrared region in order to guarantee complete night and bad weather capability of the helicopter warning system.

If, for the sake of economy, an independent identification system with its own optics and control system is not employed, the identification time strongly influences operation of the system, especially when during a single scan many "suspicious" targets are detected, which must then be identified as helicopter or false target. In further development of the invention, it is therefore suggested that the individual azimuth positions of targets identified as false returns be stored in a computer and used in a threat determination as well as subsequent direction of countermeasures. Towards this goal, the stored information is used to suppress the identification procedure over a

limited azimuth range during at least the following pass of the scanner, to prevent the identification of the same target at a slightly different angle. A threat determination is indispensable for modern fire control computers. When many targets are present, selection criteria such as distance, speed, type of target etc. are taken into consideration in order to determine which of the targets identified presents the greatest threat to the vehicle being defended.

With reference to the spatial arrangement of the three sensors, it is expedient if these are arranged in a row in a common sensor head. It is advantageous if the sensor head is set up as a periscope, turning in azimuth around its vertical axis, in which the elevation angle and horizon information are controlled by mirrors integrated with the sensors. The mirrors move independently and the periscope rotates around a ball bearing attached to its outer casing. The sensor can also be constructed as a vertically oriented fork, turning in azimuth around its vertical axis, whose arms support a shaft holding the sensors. The shaft is perpendicular to the vertical axis, and allows the sensors to move in elevation. The motion in azimuth is a rotation of constant speed. In elevation the motion is of periodic nature (at least in the case of the horizon sensor's mirror).

For reasons of cost and weight it is advantageous to provide the three sensors with a combined objective lens and to filter the radiation to the horizon sensor, which operates in a different spectral region than the other two sensors. This may be achieved by designing the combined objective with a broadband lens set up for wavelengths of 1.8 to 2.7 µm and approximately 3.0 to 5.5 µm (for the horizon sensor) as well as 8.5 to 12.5 µm for the detction and identification sensors). The same wavelength sensitivity is required for the detection and identification sensors due to the range requirements discussed above. On the other hand, separate sensors are required due to the widely differing tasks to which they are dedicated and their differing response characteristics. They can, however, be mounted in a common Dewar flask and cooled together to the temperature of liquid nitrogen ($77^{\circ}K$), thus saving space and weight.

As for the type of sensors and their direction of motion, one possibility for the detection sensor is a set of N individual detectors identical in size, arranged vertically in a row and movable in the horizontal direction. On the other hand, it is appropriate to form the identification sensor in the shape of a rod, with the highest possible ratio of length to width. This allows the sensor to conform to the projection of the rotor disk as well as possible. For similar reasons it is sensible to align the rod shaped sensor horizontally (i.e. parallel to the most probable orientation of the rotor blades) and located so as to follow the direction sensor as the head moves in azimuth. It is

thus possible first, to detect the attack helicopter as a warm spot with the detection sensor, determine its angular position in the field of view, and aim the identification sensor at it with azimuth and elevation control signals. In order to determine the rotor frequency, a necessary item for identification manifesting itself as an amplitude modulation of the infrared signal, the rotor blades must be kept in the identification sensor's field of view for approximately 1 second.

To improve the speed of the identification sensors, it is advantageous to tie in the sensors with an acoustic identification sensor, moving in a slaved fashion in azimuth and elevation, and consisting of at least one directional microphone. With this, or, alternatively, with a Fourier analysis of the sound waves, one can determine whether characteristic acoustic frequencies of an attack helicopter's rotor are present, which aides in location and identification.

Other features of the invention are, first, the scan frequency of the mirror associated with the horizon sensor is tuned to the rotational speed of the sensor head, and second, the mirror's scan amplitude is greater than the angular field of view in elevation at any given time. Furthermore, with the aide of an angular position transducer the position of the horizon is determined and used to aim the detection sensor in elevation by means of the rotatable mirror.

The following discusses examples of applications of the invention. In the figures, components which are identical in more than one figure carry the same reference number.

Fig. 1: General arrangement of a helicopter warning system built like a periscope with three sensor assemblies for target detection, helicopter identification, and determination of the position of the horizon.

Fig. 2: General arrangement of a helicopter warning system integrated in a fork-shaped assembly.

Fig. 3: Schematic view of the optical light paths of a helicopter warning system with broadband objective lens, splitter, and separate horizon sensor with scanning mirror.

Fig. 4: Depiction of the horizon showing the scanning motion of the horizon sensor and the region monitored by the detection sensor, in which the helicopter can also be identified.

Fig. 5: Schematic presentation of the combined detection and identification sensor with a sensor array for detection and a rod shaped sensor for identification of helicopters.

Fig. 6: Schematic presentation of the azimuthal rotation speed of the horizon sensor, when during the first pass a point target is identified as a false target and the identification process is initiated and during the

following passes the angular range of the false target or helicopter is not monitored.

In the periscope version of the helicopter warning sensor in Fig. 1, the sensor head 1 is hung on a ball bearing 2 attached to its outer casing. The rays from the image shown as the dotted lines 3 are deflected with the deflection mirror 4, which can be moved in elevation around shaft 5, and fall on the splitter 6, which lets through rays for target selection, which are focused with lens 7 on the detection sensor 8, while the rays for the identification sensor and the horizon sensor are reflected. A further splitting follows in splitter 9, where the rays for the identification sensor are reflected and focused by the attached lens 10. The rays for the horizon sensor pass through, fall on the scanning mirror 12, and from here are focused on the horizon sensor with lens 13. The field of view is scanned with the scanning mirror 12 in order to determine the position of the horizon, whereby the scan frequency of the mirror is tuned to the rotational frequency of the sensor head. The deflection mirror 4 is made large enough so that the fields of view of lenses 7, 10, and 13 are encompassed. The scanning of sensors 8 and 11 takes place through rotation of head 1 around its vertically aligned rotational axis 17. In addition, for the horizon sensor 14 a motion in elevation is required, which takes place through scanning mirror 12.

For the version in Fig. 2 the helicopter warning sensor is of compact design. The three sensor assemblies 8, 11, and 14 are integrated with their respective lenses 7, 10, and 13 as separate units mounted next to each other in a row. In this version the splitter and deflection mirror are omitted. The latter's function is taken over by the horizontal shaft 15, which allows the sensor group to be turned in elevation relative to the fork-shaped sensor head 1 by means of drive elements not shown in the figure. The sensor head 1 can in turn be rotated in azimuth around the vertical shaft 17. The acoustic identification sensor 18 with the two directional microphones 19 and 20, shown only in this version, is possible with other versions as well. A directional determination of the sound waves is possible through the offset between the two directional microphones 19 and 20.

Fig. 3 shows the general arrangement of a helicopter warning system with the broad-band lens 21, for the spectral ranges of 1.8 to 2.7 µm and 3.0 and 5.5 µm wavelength for the horizon sensor 14 and the range of 8.5 to 12.5 µm in wavelength for the detection sensor 8 and the identification sensor 11, both of which can be viewed in figures 1 and 2. In this example the detection and identification sensors are mounted in a common Dewar flask 22, while the horizon sensor 14 is separate and receives its signal through the spliter 9 and the scanning mirror 12. In another example, not pictured, it is possible to mount the detection and identification sensors in separate Dewar flasks if one introduces the

additional splitter 6 as shown in Fig. 1. Such a separation of the detection and identification sensors only makes sense when the two sensors operate in separate spectral regions.

Fig. 4 shows how the horizon sensor 14 is used to control the elevation angle of the helicopter warning sensor. The arrow 24 shows the scan direction and the line 25 the horizon, while the location 26 identifies a sensor array, consisting of the individual sensors 8. When the oscillating frequency of the scanning mirror 12 (Fig. 1 and 3) is tuned to the rotational frequency of the sensor head 1 (fig. 1 and 2) and the oscillation amplitude is chosen to be greater than that of the instantaneous elevational field of view of the sensor array 26, the horizon sensor 14 (fig. 1 to 3) moves over the scene along the saw-tooth curve 27 and determines the position of the horizon at the points 28, at which a step change in the incident radiation occurs. The position of the horizon can be determined through an angular position transducer not shown, and used to pre-aim the detection sensor in elevation through the rotating mirror 4. The detection sensor or sensor array 26 monitors thereby the region around the horizon depicted by the shaded band 29.

In the combined detection and identification sensor in Fig. 5 the detections sensor 26 is built up from a vertically arranged row of individual sensors 8 with as little separation between the sensors as possible and the identification sensor 30 as a rod shaped sensor with a large length to width ratio. The latter is separated as far as possible from the middle sensor 8' of the detection sensor. This separation, shown as the double arrow 31, results in an azimuthal lag angle of the identification sensor relative to the detection sensor, determined by the rotational speed of the sensor head,

which scans in the direction of the arrow. This lag angle is used for the direction of a detected target onto the identification sensor, since the sensor head is rotated far enough in the elevation direction.that the detected target during rotation is guided onto the identification sensor. After cessation of the rotation of the sensor head the unidentified target can be identified as attack helicopter or false target.

The time history of the identification procedure is presented in Fig. 6, with the angular velocity ω_T of the sensor head. If at time T_A the detection sensor picks up a target, the rotational speed is reduced to zero within a certain time. At the same time, the sensor is moved in elevation in such a fashion, that the identification sensor receives signals from the unidentified target at time T_B. When the identification process is concluded at time T_C, the rotation resumes with constant angular velocity ω_P, and if the target was identified as a helicopter, the target's position is sent to a computer for further processing. In the case of false targets, a false target signal is sent. In either case the position of the target is stored and used for several passes to prevent initiation of the identification procedure at time T_A during the time interval ΔT_A, so as not to analyze every previously identified target with every successive pass of the scanner and thereby delay the scanning process. Targets, which are acquired before the time T_A and after the time $T_A+\Delta T$ for the first time, do of course result in initiation of the identification procedure.

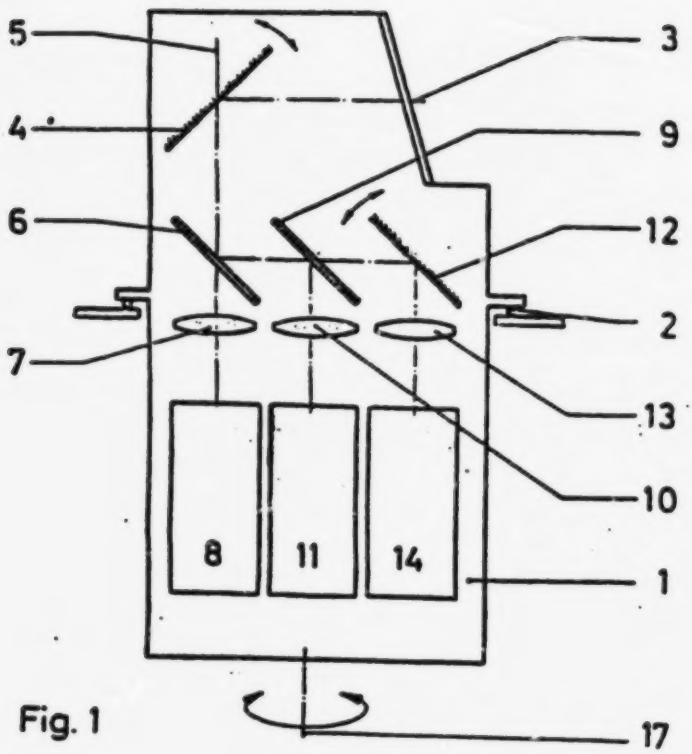

Fig. 1

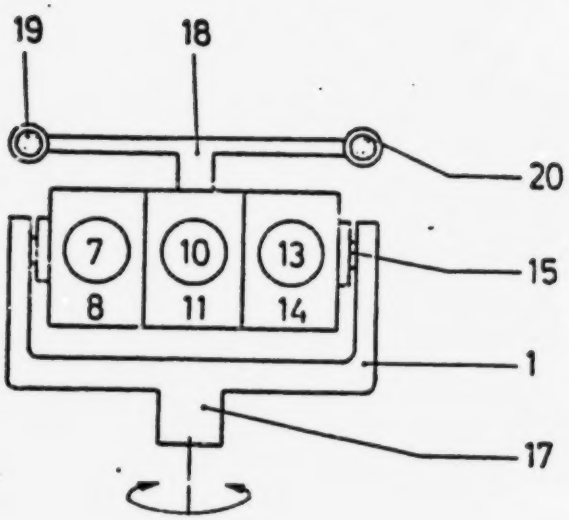

Fig. 2

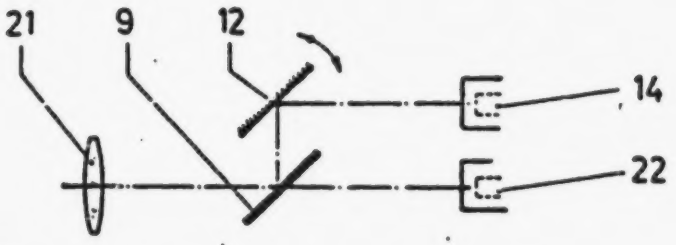

Fig. 3

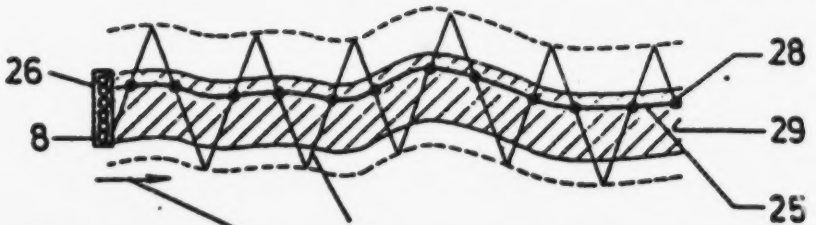

Fig. 4

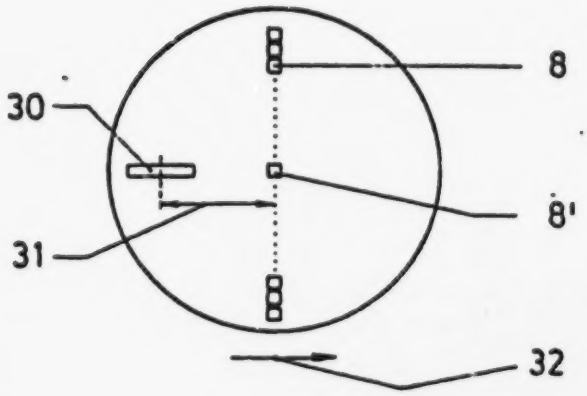

Fig. 5

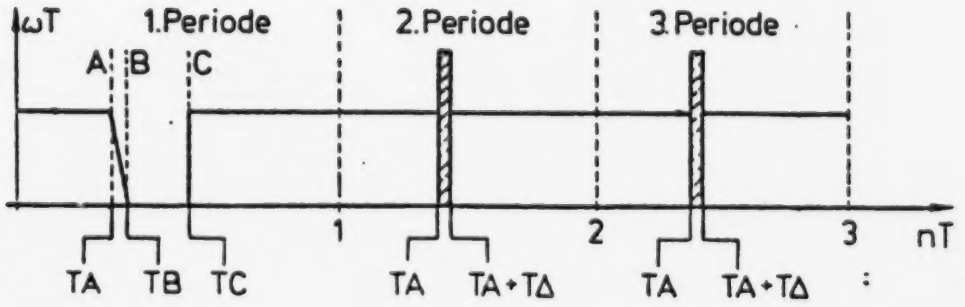

Fig. 6